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This Week's Citation Classic

Bancroft J B. The self-assembly of spherical plant viruses. *Advan. Virus Res.* **16**:99-134, 1970. [Dept. Botany and Plant Pathol., Purdue Univ., Lafayette, IN]

A description of certain icosahedral and related viruses and the methods by which they may be disassembled and reassembled is presented. The icosahedral and tubular products formed in the presence and absence of nucleating agents are specified in detail. The production of hybrid viruses is also described. [The SCI® indicates that this paper has been cited over 95 times since 1970.]

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"This paper was a review largely of the work of myself and my associates, principally Roy Markham and Graham Hills at the Virus Research Institute in Cambridge, and Ernest Hiebert and Grant Wagner at Purdue University. I had been searching since the early 1960s, along with a number of other people interested in assembly processes at various places, for an icosahedral virus that had properties which would make it a good candidate for the first demonstration of the self-assembly of such a structure as predicted from theoretical considerations.[1]

"Preliminary information that I did indeed have a good candidate was gained at Purdue just before I was awarded a National Science Foundation senior postdoctoral fellowship for a year in Cambridge which would provide the opportunity for uninterrupted research. Within three months, I was able to show that protein could be obtained from ribonuclease-treated virus which had been induced to assume a certain configurational state, which would assemble into a variety of forms, including tubes. The various products and conditions for making them were systematically investigated using a variety of techniques including optical diffraction methods which have become more popular since the advent of cheap lasers. A rather large paper[2] was written which elicited about 1,500 requests, which was somewhat embarrassing since we hadn't ordered many reprints.

"The next major step was to isolate pure protein in the absence of a nuclease. From detailed configurational studies monitored largely by centrifugal and diffusion methods, I was able to deduce that carboxyl-carboxylate pairs were probably involved in the configurational change and assumed that in a certain state, the virus was largely held together by charge-charge interactions between the protein and nucleic acid which would be responsive to counterions. Thus, virus in that state was simply treated with 1 M NaCl to cause it to disassemble and the RNA which was relatively compact under such conditions was sedimented, the protein remaining in the supernatant fluid. Such protein was combined under specified conditions with RNA and the reconstituted product was shown to share properties with the natural virus. The short paper[3] resulting from this work also attracted considerable attention and formed the basis for a series of detailed papers on various aspects, including the production of capsids, of the system. These papers, along with the two seminal ones, constituted the major part of the review. Subsequent assembly attempts by other workers with various plant viruses were also described so that the review encompassed just about all that was known at the time. Since little significant new knowledge has emerged since then, this is probably only one of two[4] fairly complete papers that can be conveniently cited about the assembly of simple icosahedral viruses and as a consequence, it has apparently gained some popularity."

1. **Caspar D L D & Klug A.** Physical principles in the construction of regular viruses. *Cold Spring Harbor Symp.* **27**:1-24, 1962.
2. **Bancroft J B, Hills G J & Markham R.** A study of the self-assembly process in a small spherical virus. Formation of organized structures from protein subunits *in vitro*. *Virology* **31**:354-79, 1967.
3. **Bancroft J B & Hiebert E.** Formation of an infectious nucleoprotein from protein and nucleic acid isolated from a small spherical virus. *Virology* **32**:354-6, 1967.
4. **Hohn T & Hohn B.** Structure and assembly of simple RNA bacteriophages. *Advan. Virus Res.* **16**:43-98, 1970.